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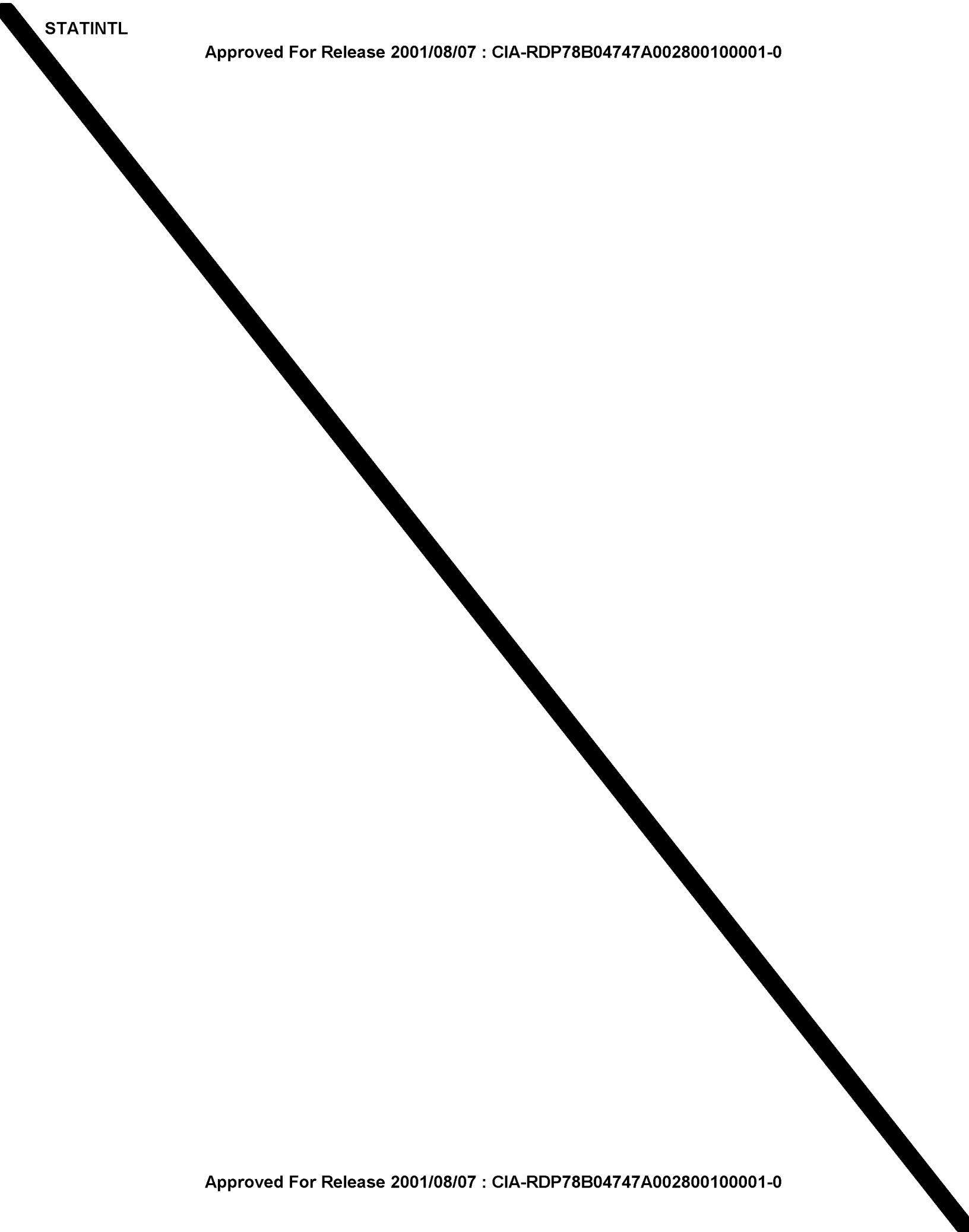

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REPORT 974-006-1

PERFORMANCE EVALUATION OF A POSITIVE-PRESSURE TRANSPORT CAPSTAN

RM-137-65

June 1965

STATINTL

[redacted]

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FOREWORD

STATINTL [redacted] submits this report in compliance with Item 4.2 of the Development Objectives of Contract 974.

STATINTL [redacted]

Approved:

Research Manager

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ABSTRACT

An investigation was conducted on a new technique for generating and applying a vacuum to a rotating film-drive capstan. The diameter of the capstan was established as a result of the tests conducted under Assignment 974-002.

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ILLUSTRATIONS

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1. INTRODUCTION

A program of investigation on a new technique for generating and applying a vacuum to a rotating film-drive capstan was conducted. This technique involves the generation of a vacuum by passing high-velocity air through a shaped annular orifice and connecting vacuum lines to an opening in the throat of this orifice.

Two capstans were fabricated for this program. The first one, 3 inches in diameter, was used to obtain most of the test data given in this report (Figure 1). A second capstan is a working model that will drive all film widths from 70mm to 9-1/2 inches in base thicknesses to 0.012 inch. It is 6 inches in diameter so that undue forces will not be required for the sole purpose of bending film.

2. TECHNICAL DISCUSSION

The vacuum capstan is operated on the venturi principle to generate a vacuum in the rotating member of the capstan. Figure 2 shows a cross-section of a positive pressure capstan, illustrating the principle of generating a vacuum in an annular orifice.

Under positive pressure, air enters the capstan parallel to the axis of rotation. The air is deflected outward so that it exits from the capstan radially to the axis of rotation between a fixed and a rotating member. A circle of maximum restriction is found between the two members. This is shown at point B in Figure 2. The pressure at this restriction point is inversely proportional to a function of the velocity of the air passing through it. The capstan was so constructed that the annular opening at point B could be varied to obtain maximum effectivity at the fixed blower output.

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A total of 64 openings were made around the circumference of the capstan at the throat of the annular orifice to create a multiplicity of vacuum ports (three, however, were obscured by attaching screws leaving only 57 effective). Each of these vacuum ports is connected to the surface of the rotating member of the capstan at the point where it is desired to drive the film. The diameter of the ports at this point is 0.068 inch. In this case, it is near the midpoint of the capstan so that all sizes of film can be driven.

The force holding the film to the capstan is dependent on the differential pressure on the two sides of the film and the area over which this differential pressure is applied. A greater driving force for the film can be created by increasing the area served by each vacuum port on the capstan. This can be done by providing a rough surface around each port or by providing a pattern of grooves connected to each port.

Most capstans are required to hold film over a fixed angle, which is related to the angle of rotation. This is usually 180 degrees or less, depending on the configuration of the machine in which they are used. It is necessary that the capstan release the film at a point beyond the film wrap. This is done with the positive pressure capstan by providing a vane on the fixed member, across the outlet of the orifice, so that back pressure is created to reduce the velocity through the throat at the desired release point. If a high enough back pressure is obtained, this will not only eliminate the vacuum but will also provide a positive pressure to separate the film from the rotating capstan.

A set of tests was conducted on the 3-inch capstan to determine vacuum pressure in inches of mercury as a function of the volume, or volume of air per minute used. These results are shown in Figures 3 and 4. Each is an average of four vacuum ports in one particular position;

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that is, having one relationship to the fixed member. These positions are indicated as A and B on the curves. Above a volume rate of about 6 cubic feet per minute, the curve remains linear for the volume rate of flow. The break in these curves is unexplained at this time.

Using an Alnor Velometer, Type 3002, No. 24160, a series of static pressure readings and flow in fpm was made (Table 1) at each port with the annular opening at B adjusted for maximum. For a second test, a complete pressure traverse of the blower output was recorded to determine cfm (Figure 5). Because of the erratic flow pattern in the narrow throat of the blower (three points at 180°, 225°, and 270° read zero), it was decided to measure the total output of the blower with a recording flowmeter.

Subsequently, a large Roots Connersville meter was borrowed from the Southern Counties Gas Company. This meter has a capability of registering 23,000 cubic feet per hour in increments of 10 cubic feet at pressures up to 125 pounds per square inch. It is a Model No. 23M125, Serial No. 6504026, with calibration file No. 637-17-N65. It was 0.7 percent slow at 2300 cfm and 1.6 percent slow at 23,000 cfm. An adapter flange was built to receive the blower fan but time did not permit completion of the tests.

3. CONTINUATION PROGRAM

Comparative outputs will be measured on the blowers unrestricted and with the back pressure introduced by the capstan venturi. This will enable a calculation of the overall efficiency of this type of capstan.

It is further planned in this investigative evaluation to determine what vacuum variations exist when 50 percent (180-degree wrap) of the openings are covered by the film, wet and dry. Different widths and

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thicknesses of film and leader will be used to provide complete data on torque available for driving. Early tests showed that the vacuum falls off when part of the holes are covered. This phenomenon may be due to the venturi being out of symmetry in this condition of flow and may be dependent upon gap spacing. It must be checked empirically.

A program to compare the positive pressure 6-inch capstan to a negative pressure 6-inch capstan should prove of interest. All parameters associated with vacuum capstans would be compared. This unit can easily be connected into a vacuum capstan by reversing the flow, using the same blower and an adapter for its plenum intake. One such vacuum capstan, STATINTL developed by the [redacted] is illustrated in Figures 6 and 7.

Completion of this comparison, then, will give the processor designer his first available empirical data on which a scientifically sound choice between the types of capstan can be based.

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TABLE 1

NEGATIVE FLOW CHECKS OF CAPSTAN

No. of Holes = 57 Effective
Diameter of Holes = 0.068 Inch

Hole Sta	Static Press Ins/H_2O	Fpm	Hole Sta	Static Press Ins/H_2O	Fpm	Hole Sta	Static Press Ins/H_2O	Fpm
1	Screw	Screw	22	1.85	1525	43	1.1	1575
2	.95	1150	23	2.0	1550	44	1.2	1350
3	.95	1150	24	2.0	1550	45	1.6	1550
4	1.6	1400	25	2.3	1650	46	1.4	1475
5	1.7	1400	26	1.9	1650	47	1.5	1475
6	1.7	1425	27	2.3	1650	48	1.5	1450
7	1.7	1450	28	2.2	1700	49	1.4	1425
8	1.7	550	29	2.0	1650	50	1.4	1350
9	1.6	1425	30	2.2	1600	51	1.4	1375
10	1.9	1550	31	2.2	1650	52	1.4	1400
11	1.8	1510	32	1.9	1725	53	1.2	1300
12	2.0	1550	33	1.8	1700	54	1.5	1300
13	1.9	1525	34	1.9	1550	55	1.5	1425
14	2.0	1550	35	1.9	1525	56	1.4	1325
15	1.95	1525	36	2.0	1650	57	1.0	1400
16	2.0	1575	37	2.1	1700	58	1.4	1475
17	2.4	1700	38	1.7	1600	59	1.4	1440
18	.30	700	39	1.6	1550	60	1.0	1300
19	1.7	1470	40	1.2	1350			
20	1.75	1470	41	Screw	Screw			
21	Screw	Screw	42	.95	1200			

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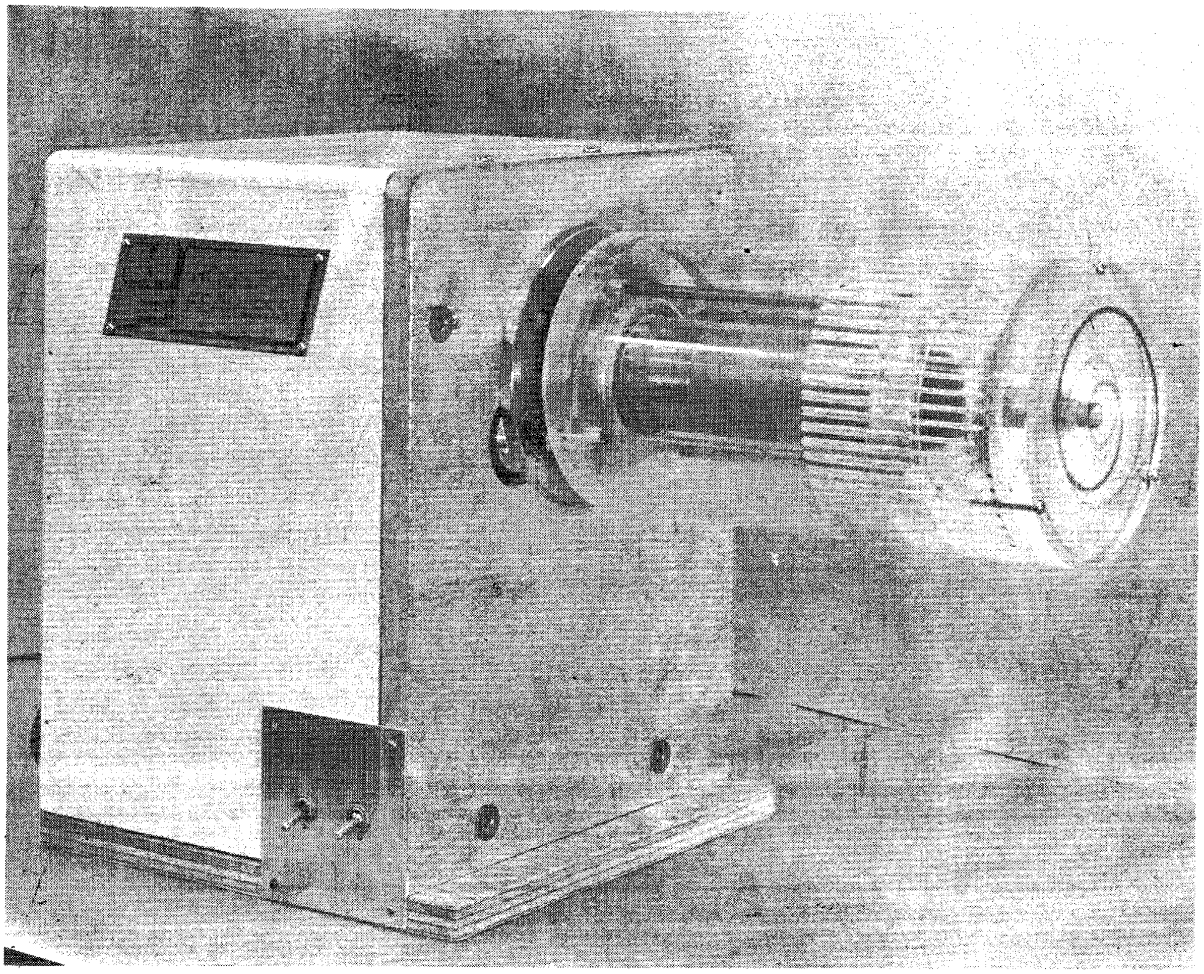

Figure 1. [redacted] Vacuum Capstan Test Model

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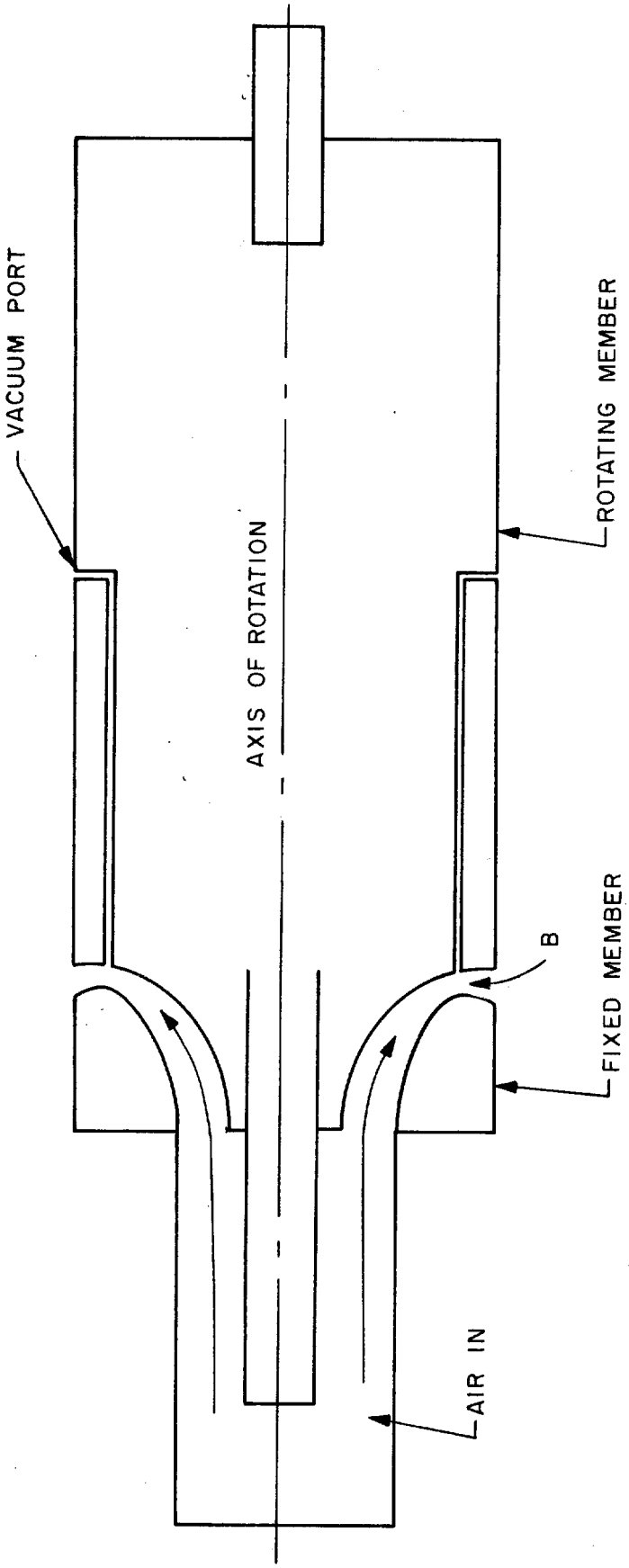

Figure 2. Positive-Pressure Vacuum Capstan

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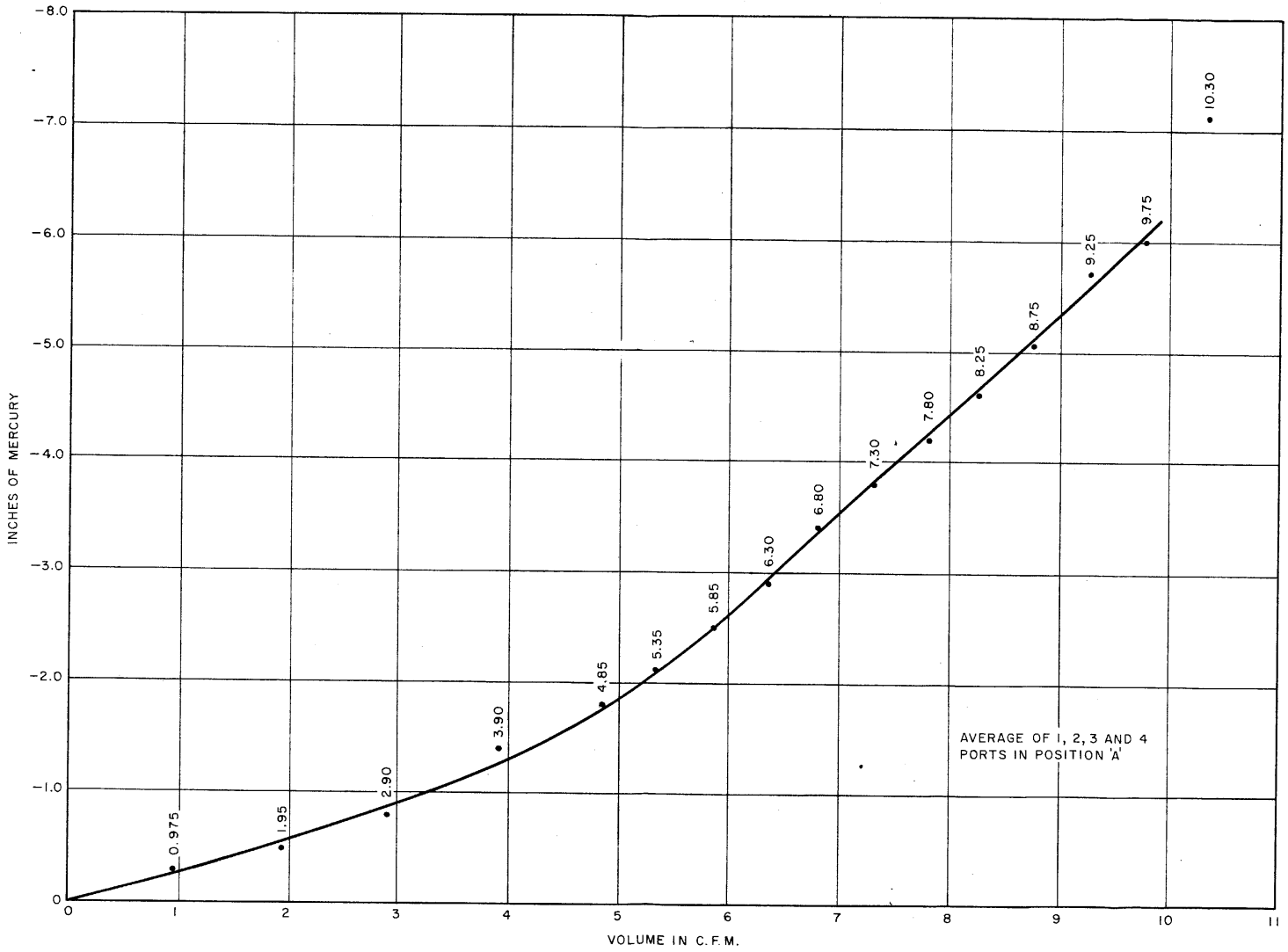

Figure 3. Vacuum Pressure as a Function of Volume with Ports in Position "A"

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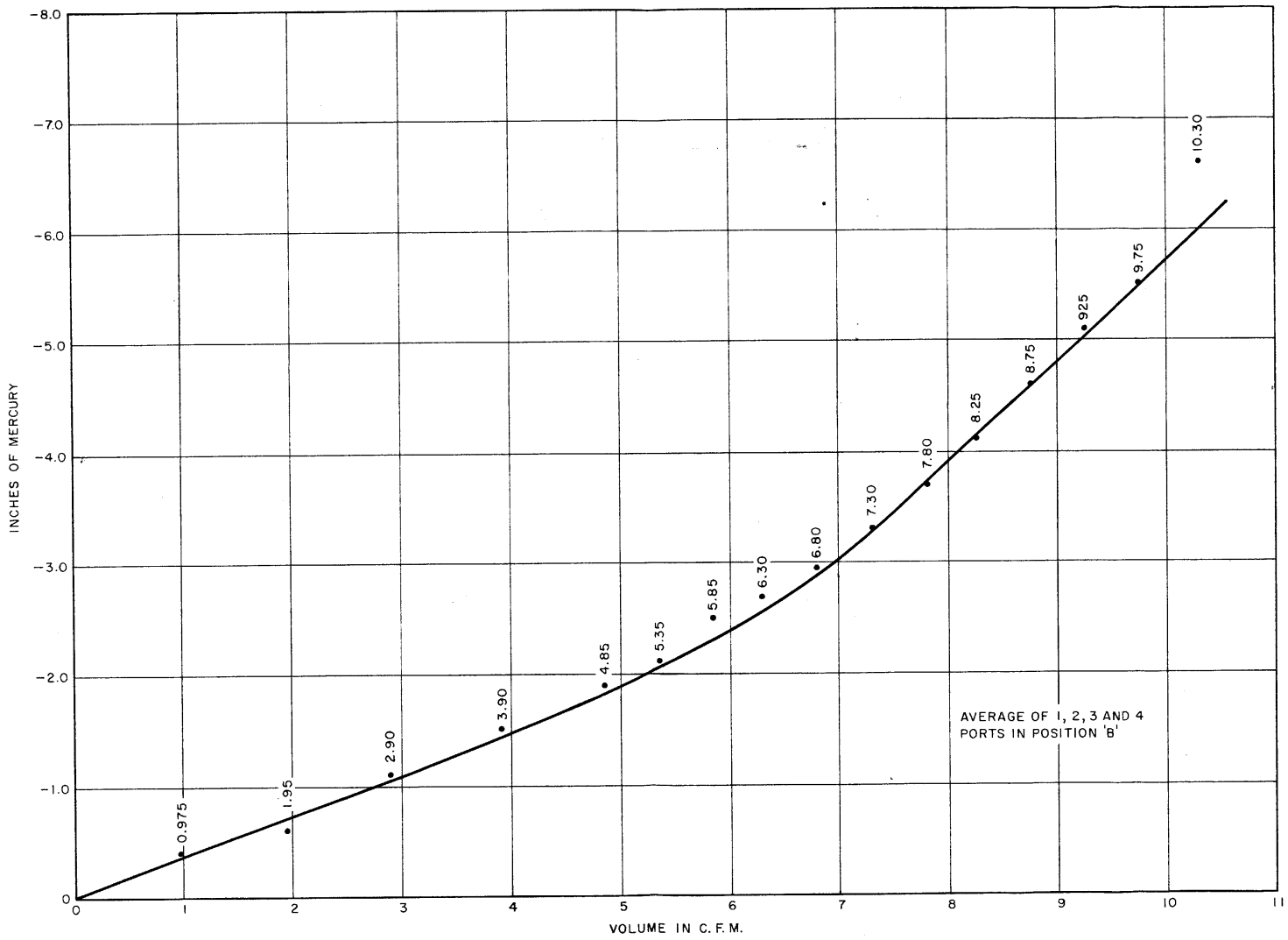

Figure 4. Vacuum Pressure as a Function of Volume with Ports in Position "B"

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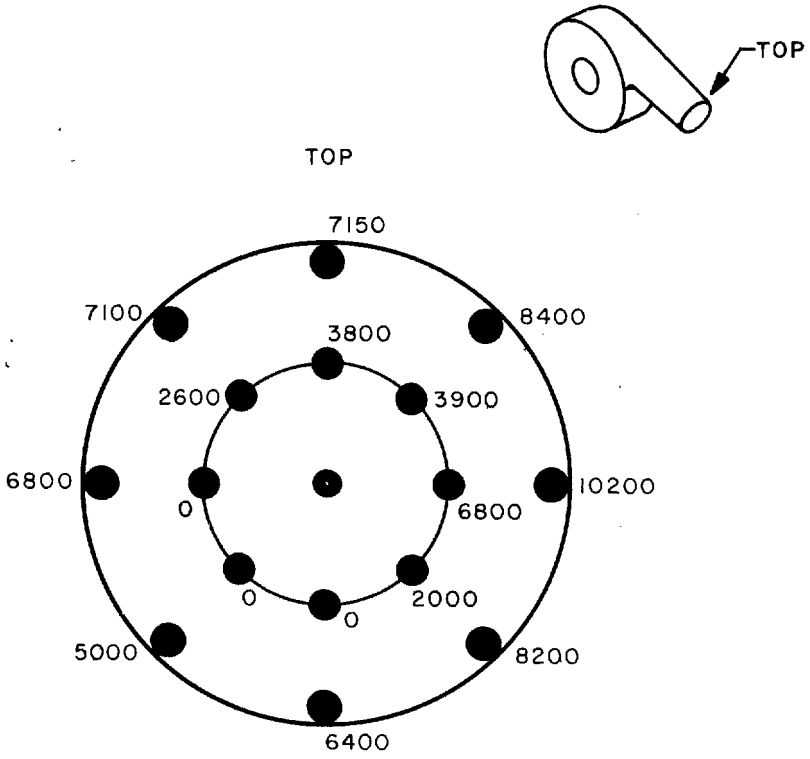

I-D OF BLOWER OUTLET = 1-7/8 IN.

CFM = AVERAGE VELOCITY (FPM) x AREA (SQ. FT.)

$$= \frac{4680 \times 2\text{-}3/4}{144} = 179 \text{ CFM}$$

Figure 5. Measurement of Blower Performance in Cubic Feet per Minute

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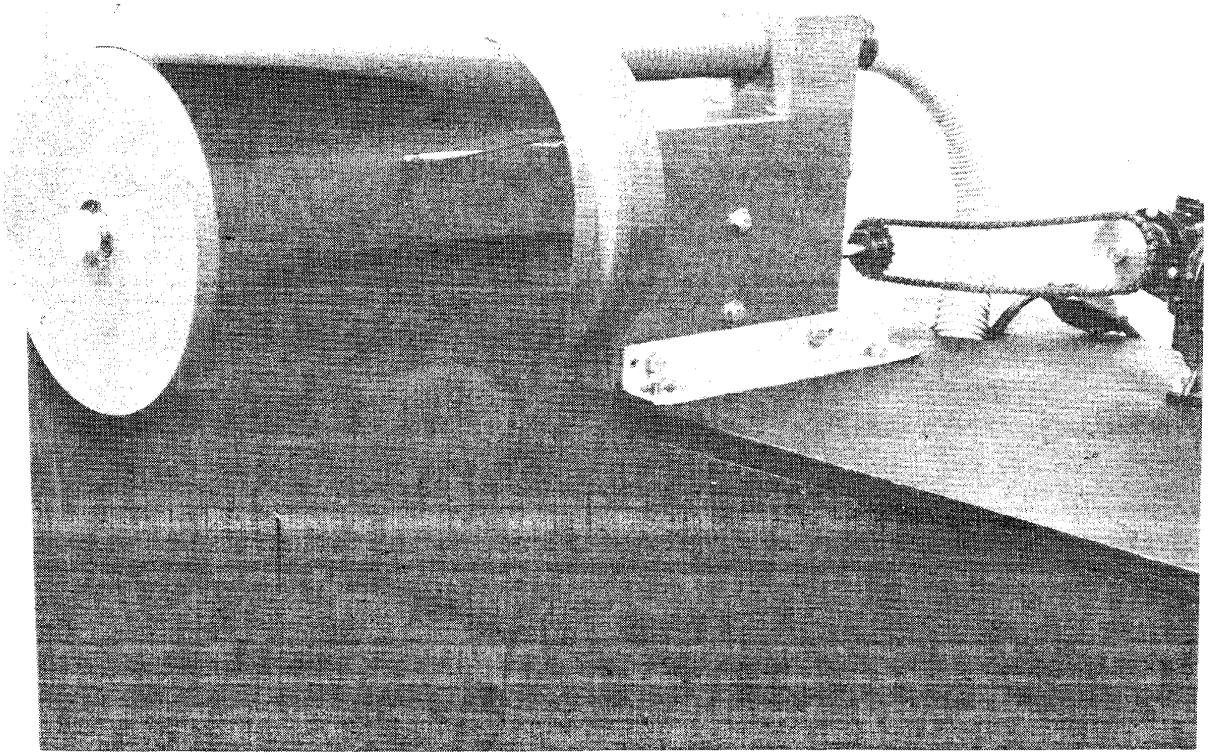

Figure 6. [redacted] Vacuum Capstan Test Model

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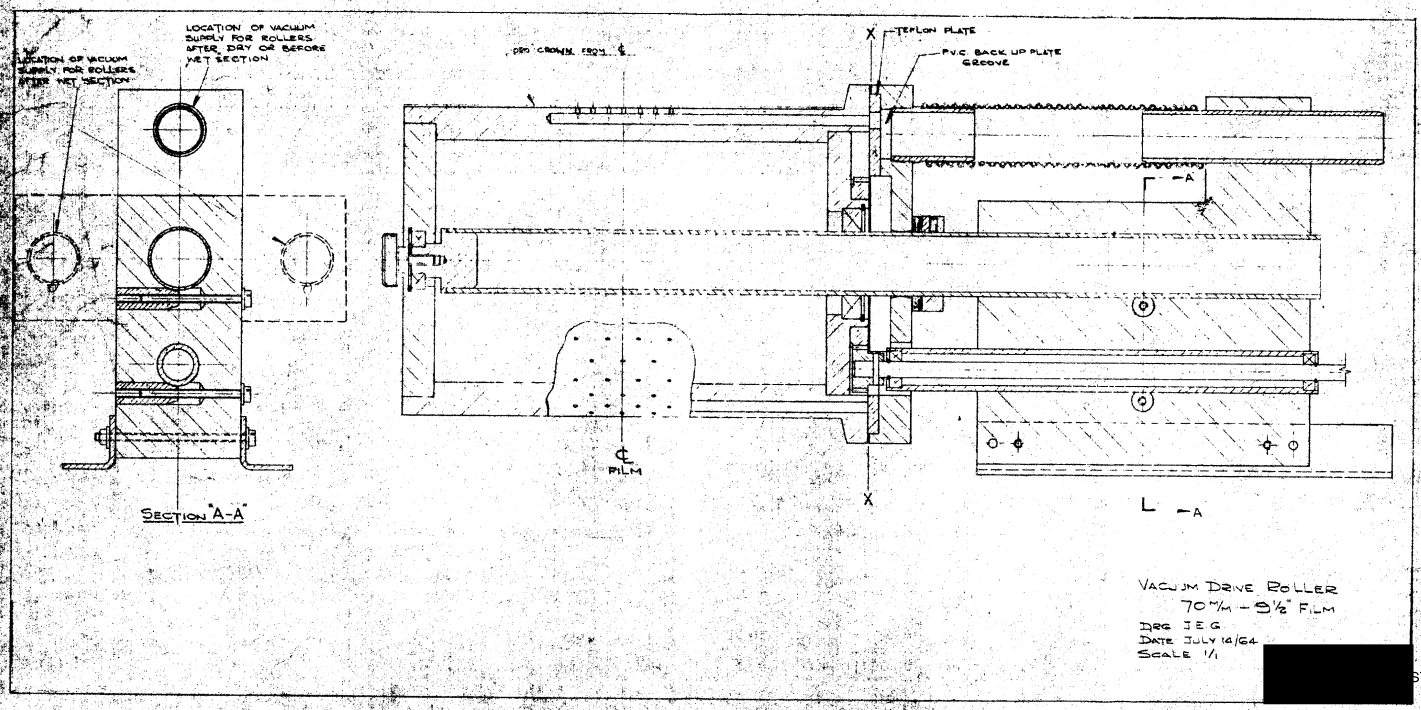

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Figure 7. [redacted] **Vacuum Capstan, Cross-Section View**

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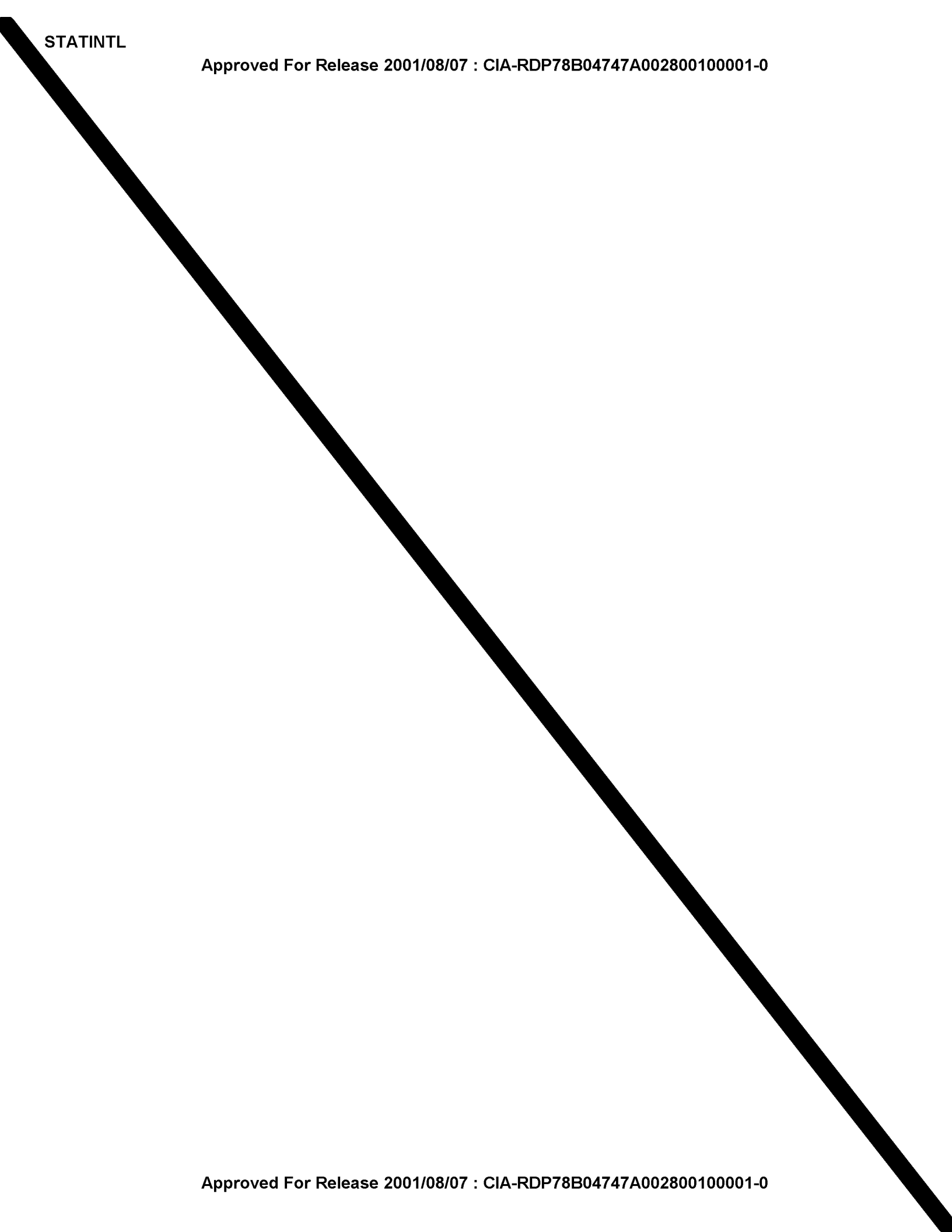

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